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PUBLISHING GLOBES ON THE INTERNET

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This paper presents possible solutions to the problem of interactive digital globe publishing on the Internet in connection with the recently opened Virtual Globes Museum. It describes the processing method of two possible source materials: globe prints and photographs. The visualization of the results is realized in two different ways. The first one is a 3D virtual world created using the VRML language. The second one is a special "globe layer" in KML, which can be used in the Google Earth software. The advantages and disadvantages of each solution are also examined.

Keywords: 3D visualization; globe museum; virtual globe

Introduction

In connection with a research running at the Department of Cartography and Geoinformatics the Virtual Globes Museum has been opened to the public (Márton 2008, Márton and Gede 2008).

The project aims the following goals:

— Developing a method of 3D globe model production from globe prints or by using photographs

— Founding the Virtual Globes Museum (Márton 2008) — a virtual exhibition on Internet open to the public — based on globes of the Cartographia Enterprise (Márton 1988, Kovács and Márton 1989)

— Developing and presenting the method of digital virtual globe restoration on a specified globe in order to free the restoration process of any risks

— Producing new (thematic) globes (Márton 1975).

There other virtual globe projects. Balázs had made a digital version from Waldseemüller's globe (Török and Balázs 2008) but the content is not the original: Only the coastlines were redrawn in a graphic software and some names were put onto it. The result is an animation which does not let the user interact.

Another project is Riedl's "hyperglobe" (Riedl 2000, 2003). This shows several ways of globe visualization. With Hruby and Plank they created the digital copy of Mercator's globe using photographs (Hruby et al. 2006). Although the processing method was quite similar to the one described here later, there are some differences: they georeferenced smaller areas and used a different software for it. They also examined alternative display technologies for better visualization (Hruby et al. 2005).

In the Virtual Globes Museum project several globes are shown in their current, real state. There is a searchable background database, which contains detailed datasheets for each globes. The models are fully interactive, visitors can spin the globes around, zoom in and out.

Materials and methods

The production of a virtual globe consists of three main steps: collecting and pre-processing appropriate materials, then creating the virtual globe itself.

There are two kinds of possible source materials. In the simple case, prints of the globe are available (Fig. 1). In this case the processing steps are the following:

— Scanning the prints. The scanning resolution should be at least 300 dpi.

— Cutting out the globe segments with a graphic software, like Adobe PhotoShop or Corel PhotoPaint.

— Georeferencing the segments. The projection of globe prints is Cassini-Soldner for the segments and Azimuthal Equidistant for the polar caps, with some distortion because the paper stretches when it is mounted to the sphere. The control points (GCP) are the intersections of grid lines. As the grid spacing is usually 10 degrees, and the size of segments is 30° by 160° (between the latitudes 80°N and 80°S), there are 68 GCPs for each segment. When defining the projection, the central latitude should be 0° and the central meridian is the average of the bounding meridians.

— Applying a digital projection transformation (transforming the original Cassini-Soldner projection of the segments to Equirectangular projection, as this allows the segments to be put together).

— Assembling the pieces into one large image.

Fig. 1. Globe print

Fig. 2. Photographing a globe

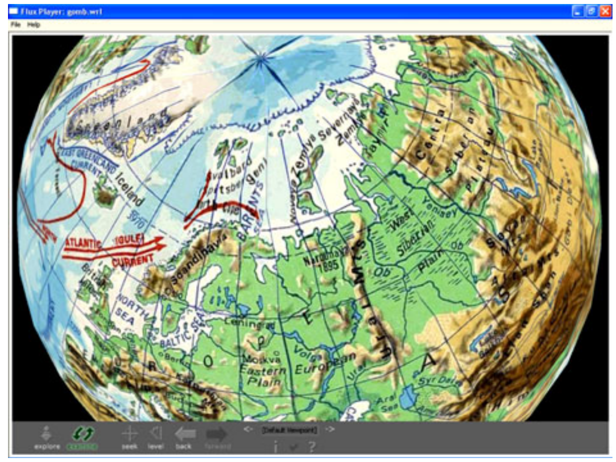

Fig. 3. The interference between the edges of the polyhedron representing the sphere and the grid lines

The Global Mapper software was used for the georeferencing, for the projection transformation and for assembling the pieces.

If the prints are not available (or don't exist e.g. the globe is a manuscript) then a series of photographs needs to be taken of the globe (Fig. 2). This procedure requires great attention and professional photographic skills as the photos need to have the same colour temperature otherwise the assembled picture will be mosaic-like. The picture processing steps are:

— Georeferencing the photos. The projection of the photos is the so-called Tilted Perspective projection which is not known by any programs. But if the globe's centre is on the optical axis then it is Near-side Perspective projection. In order to determine the parameters (the geographic co-ordinates of the projection centre and the height of the camera) the author developed a little program which uses the simplex algorithm to find these values using the given control points which are the intersections of grid lines.

— Digital projection transformation to Equirectangular projection.

— Cutting out the usable area of the pictures (usually a maximum size of 20 by 40 degrees). If the globe's centre is far from the optical axis (the projection is tilted), only a smaller area can be used.

— Assembling the pieces.

The next problem is the visualization. The solution must be easy to use and publishable on the Internet.

The first, obvious solution is the using of VRML (Virtual Reality Modeling Language) (Carey and Bell 1997). This language was developed in the 1990's to define virtual worlds. Its great advantage is that the 3D objects can be embedded

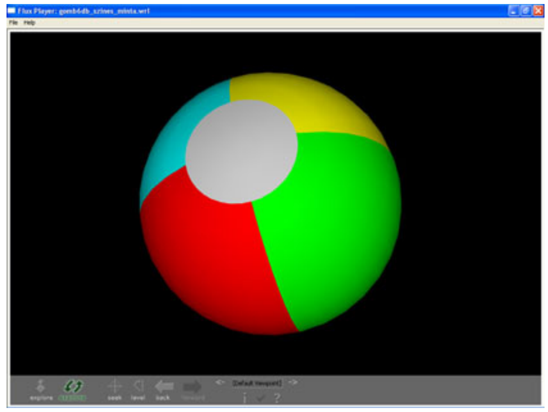

Fig. 4. The self-defined sphere built up of six surfaces

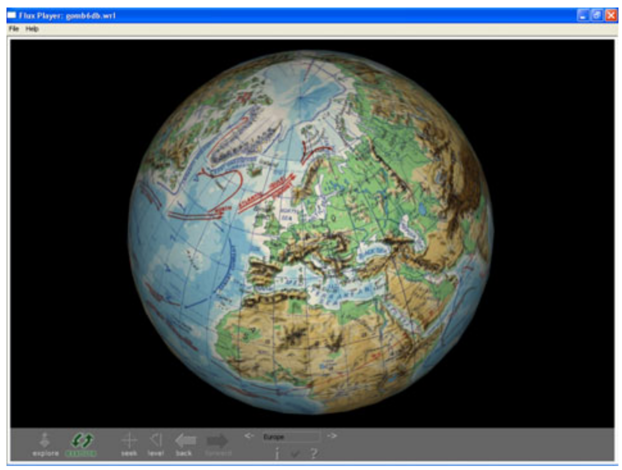

Fig. 5. Virtual globe on the self-defined sphere

into the web pages and the required plug-ins can be downloaded easily. The language supports the use of textures on surfaces, so the first version of the virtual globe was very simple: the built-in sphere object of VRML was given an image of the world in Equirectangular projection as a texture, and the interactively steerable globe instantly appeared on the computer screen.

This solution however, is not as perfect as it seems to be at first sight. The VRML sphere object is represented by a polyhedron and its edges don't match the gridlines. This results in zigzagging lines, mostly at higher latitudes (Fig. 3). Another problem is that VRML browsers don't support texture images larger than $2048 \cdot 2048$ pixels. This means less than 100 dpi equatorial resolution at a 16 cm diameter globe which makes impossible to reproduce all the details.

To solve both problems the author defined a new shape which consists of six

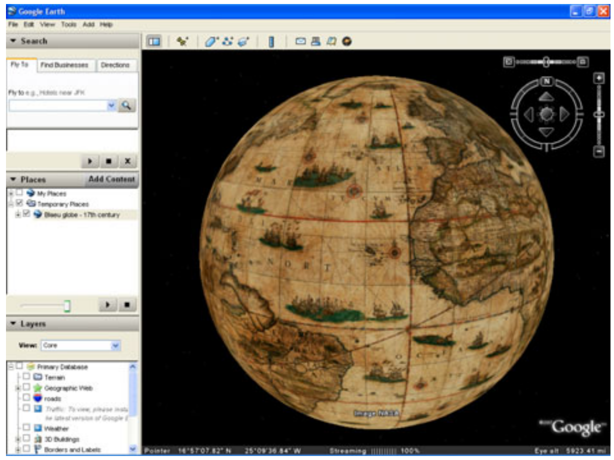

Fig. 6. The 68 cm diameter globe of Blaeu in Google Earth

surfaces. The edges match the ten-degree grid lines so the grid no longer crosses the shape edges. The six surfaces allow higher resolution as all surfaces have their own textures. Two of them are round the poles above the $\pm70°$ latitude; the rest four divides the remaining area to equal parts (Fig. 4).

As the navigation with the mouse in the virtual space requires some skill and practice, the author also defined some pre-programmed viewpoints for the globes: one for each continent and for the poles.

This model (Fig. 5) works well with medium-size globes, assuming that we use a decent computer. A considerable part of web-surfing users however use old, poor-performance computers. On these machines the models won't work properly, sometimes they even freeze the system. Above all the six surfaces are not enough for bigger globes. Defining more parts is not the right solution because it slows down the browser.

All these problems are solved by the following solution which is a "globe layer" for the program Google Earth. This program can deal with a large amount of high resolution data. It is also obvious as most user thinks of this program when they hear the phrase "virtual globe".

Anyone can define images to specified geographical quadrangles in Google Earth using the KML language. The structure of the language (Google 2008) is simple and the results are excellent: a 68 cm globe of Blaeu can be examined either as a whole or in the smallest details (Figs 6–7).

The advantage of this solution is that the globe can be combined with any other data in Google Earth: we can examine together the old and current boundaries, coastlines etc.

Of course this solution is not perfect so far: the polar areas are never viewed correctly in Google Earth. It is not a big problem however, because the content of the globes is rare at the poles. (Sometimes these areas are not even visible because of the hanging up of the globe).

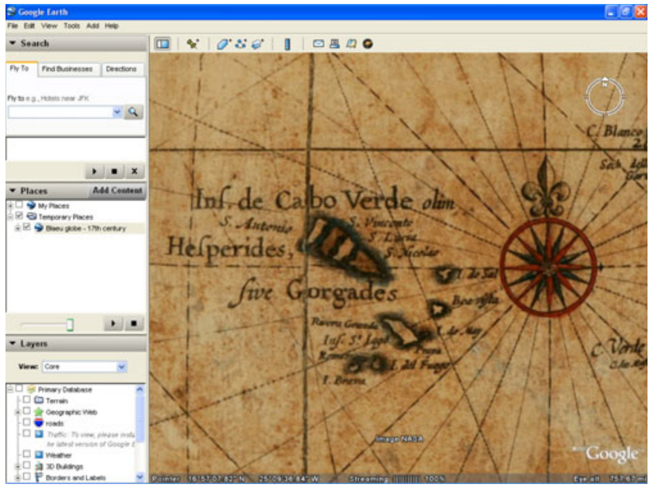

Fig. 7. Even the small details can be examined in Google Earth

Discussion

The method described above seems to be simple but the realization brings some problems: The globe should be dismounted of its hanging during the photographing. When the Blaeu globes were processed we had the permission to do it but we did not manage to remove the brass meridian ring. That is why its parts are visible at the poles. If it is not possible to dismount the hanging (not permitted or physically impossible) the camera must be moved around the globe which means different lighting conditions and causes tone differences between the photos.

The accuracy of georeference of a globe photo depends on the distance of the globe centre from the optical axis. The greater the distance is the smaller area of the photo can be used. The criteria the author used to determine this area was that the exact place of the geographic grid lines on the georeferenced image must be within the original grid line. As these lines on the photos are usually 2–3 pixels wide, this is the maximum error of the georeference. Of course it means different values in geographic co-ordinates according to the different globe diameters.

The Google Earth globe layer provides a great opportunity to compare the real, current geographic features to a globe's content. For example, before the invention of the chronometer the longitude measurements on the sea were very inaccurate. The effect of this can be perfectly studied on Blaeu's globe when the current coastlines are switched on: the further east (or west) we go from the Strait of Gibraltar the greater the distance is between the globe's and the real coastline. This tendency however, is not globally observable: the western coasts of Australia (Hollandia Nova at that time) are quite correct. An ancient globe layer can be an excellent visual tool for anyone who wants to study differences like this.

Conclusions, further plans

None of the two solution described above is perfect but each can be useful in different cases. The VRML model is better when the only task is to visualize the original globe itself, and its diameter is not more than 15–20 cm. For greater globes, and if we want to add some more content for the globe (by selectable layers) the Google Earth file is the right choice. At the Virtual Globes Museum visitors can try both models for each globe and decide which is better for their purpose.

The further plans include the development of an educational tool — a globe with various selectable themes — and the development of virtual digital globe restoration and facsimile making — a method that would allow damageless globe renewing as all the modifications would be made on the virtual copy of the globe.

Acknowledgements

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